

AFE 76s2 Report

Derivation of Radar Altimeter Interference Tolerance Masks

**Volume I: Introduction,
Test Procedures, and
Fundamental Test Results**

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3 Fundamental Test Results

3.1 Test Results Summary

Data collected for each RA tested are summarized in Table 3-1 for each test condition, grouped by UC. Numbers in the table are the break points in dBm and “NB” indicates that there was no break point observed. Each cell represents a single power sweep. The last two rows give the interference tolerance values in dBm and dBm/MHz, as described in Section 2.3.4.6, and correspond to the values provided in the ITM curves in the RTCA MSG Report.

Table 3-1: Measured Thresholds in dBm - Out-of-Band Fundamental Emissions

Usage Category 1												
Altimeter	200 ft, VCOs On (WCLS)			1000 ft, Own-Ship VCOs			5000 ft, Own-Ship VCOs			7000 ft, Own-Ship VCOs		
	3750 MHz	3850 MHz	3930 MHz	3750 MHz	3850 MHz	3930 MHz	3750 MHz	3850 MHz	3930 MHz	3750 MHz	3850 MHz	3930 MHz
F	-13	-15	-16	-20	-21	-24	-27	-28	-30			
L	NB	NB	NB	NB	NB	NB	-9	NB	NB			
T	NB	NB	NB	NB	NB	NB				NB	-7	-14
X	NB	NB	-6	NB	-8	-14	-11	-26	-24			
Y	-9	-8	-5	-15	-14	-17	-25	-25	-26			
ITM (dBm)	-19	-21	-22	-26	-27	-30	-33	-34	-36	-7	-13	-20
dBm/MHz	-39	-41	-42	-46	-47	-50	-53	-54	-56	-27	-33	-40

Usage Category 2									
Altimeter	200 ft, VCOs On (WCLS)			1000 ft, Own-Ship VCOs			2000 ft, Own-Ship VCOs		
	3750 MHz	3850 MHz	3930 MHz	3750 MHz	3850 MHz	3930 MHz	3750 MHz	3850 MHz	3930 MHz
A	NB	NB	NB	NB	NB	-7	-10	-15	-20
I	-30	-50	-32	-31	-28	-25	-28	-27	-25
S	NB	NB	NB	NB	NB	NB	NB	NB	NB
V	-50	-40	-42	-60	-46	-50	-68	-55	-63
ITM (dBm)	-56	-56	-48	-66	-52	-56	-74	-61	-69
dBm/MHz	-76	-76	-68	-86	-72	-76	-94	-81	-89

Usage Category 3			
Altimeter	200 ft, Own-Ship VCOs		
	3750 MHz	3850 MHz	3930 MHz
A [†]	NB	NB	NB
I	-30	-30	-28
S	NB	NB	NB
V	-42	-38	-37
ITM (dBm)	-48	-44	-43
dBm/MHz	-68	-64	-63

[†] – See explanation in Section 3.4.2.

The following sections provide time history and statistical plots for all entries in Table 3-1 along with a description of how the threshold value was determined in each case.

Two tables are presented for each UC/height test case. The first provides a summary of the interference test conditions used for the test case. The in-band interference representative of the WCLS is only present for UC1 and UC2 at altitudes of 200 feet AGL. In other cases, the presence of in-band FMCW RF radiation from own-ship altimeters was adjusted to match the specific AUT's support of single, dual, or triplex installation. The FMCW signal type is either triangle or sawtooth, depending on the AUT, or a mixed case of both for the WCLS.

The second table provides a summary of all threshold criteria for each UC/height test case. The criterion with the lowest power that establishes the break point shown in Table 3-1 is highlighted in pink shading. In cases where more than one criterion is exceeded at the same power level, the first threshold criterion that is applied is NCD, then mean error, then 1st percentile, then 99th percentile. Thresholds that were determined by the engineering judgement of the subject matter experts are indicated with an asterisk.

3.2 Usage Category 1

3.2.1 200 Feet AGL

3.2.1.1 Summary

Table 3-2: UC1 200' AGL Test Conditions

Source	Rationale	Signal Type	Characteristics	Setting
VSG	5G Fundamental OOBI	OFDM	100 MHz TM1.1 centered at 3750 MHz, 3850 MHz, 3930 MHz	Power Sweep
VCOs 1-2	Own-ship multiplex installation	FMCW	CF: 4300 MHz BW/Sweep Rate per AUT	ON
VCOs 3-16	WCLS – other aircraft	FMCW	CF: 4300 MHz BW/Sweep Rate per Table 2-4	ON

Table 3-3: UC1 200' AGL Out-of-Band Fundamental Emissions Break Points

Altimeter	200 ft, VCOs On (WCLS)											
	3750 MHz				3850 MHz				3930 MHz			
	ME	1%	99%	NCD	ME	1%	99%	NCD	ME	1%	99%	NCD
F	-13 dBm	-13 dBm	NB	NB	-15 dBm	-15 dBm	NB	NB	-16 dBm	-16 dBm	NB	NB
L	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
T	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
X	NB	NB	NB	NB	NB	NB	NB	NB	-6 dBm	-5 dBm	NB	NB
Y	-9 dBm	-9 dBm	NB	NB	-8 dBm	-8 dBm	NB	NB	-5 dBm	-5 dBm	NB	NB
ITM	-19 dBm				-21 dBm				-22 dBm			
PSD	-39 dBm/MHz				-41 dBm/MHz				-42 dBm/MHz			

3.2.1.2 Altimeter F

Table 3-4: UC1 RA-F 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-1	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-2 Figure 3-3	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -13 dBm. 1 st percentile measured height is less than the -2% criterion threshold at -13 dBm.
3850 MHz	Time History Figure 3-4	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-5 Figure 3-6	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -15 dBm. 1 st percentile measured height is less than the -2% criterion threshold at -15 dBm.
3930 MHz	Time History Figure 3-7	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-8 Figure 3-9	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -16 dBm. 1 st percentile measured height is less than the -2% criterion threshold at -16 dBm.

Center Frequency = 3750 MHz

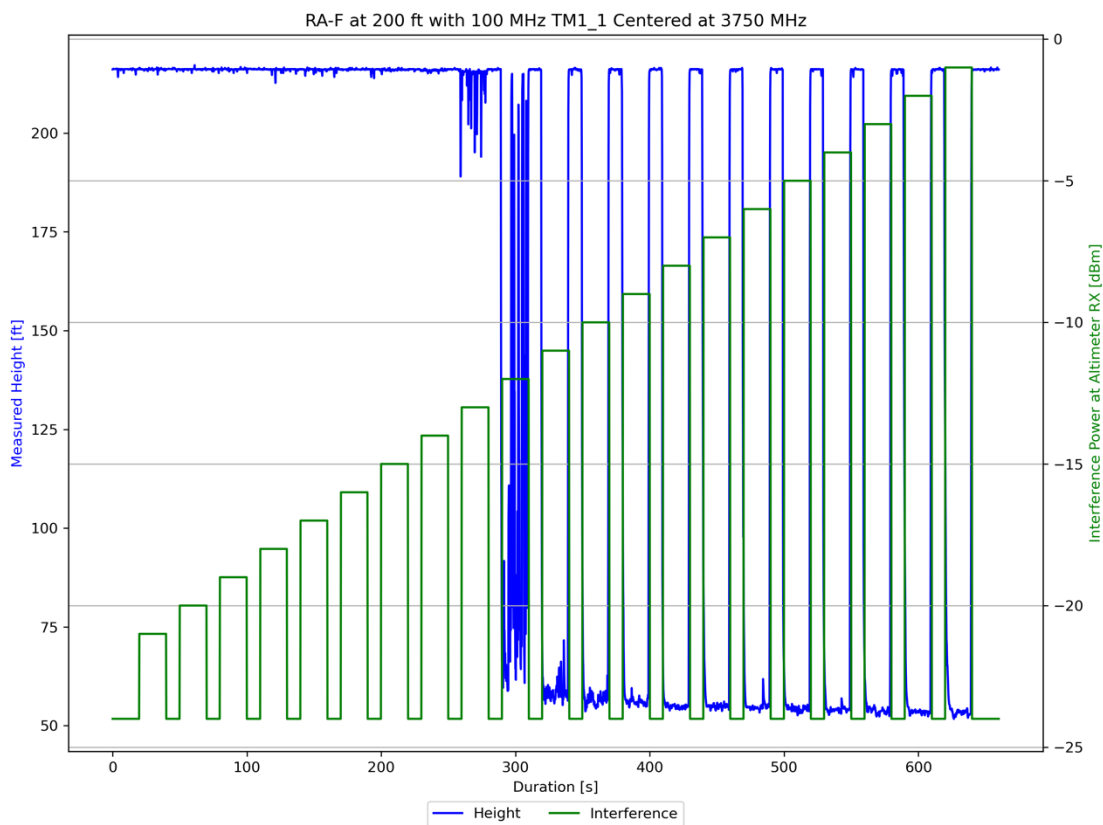


Figure 3-1: UC1 RA-F 200' AGL Time History with TM1.1 at 3750 MHz

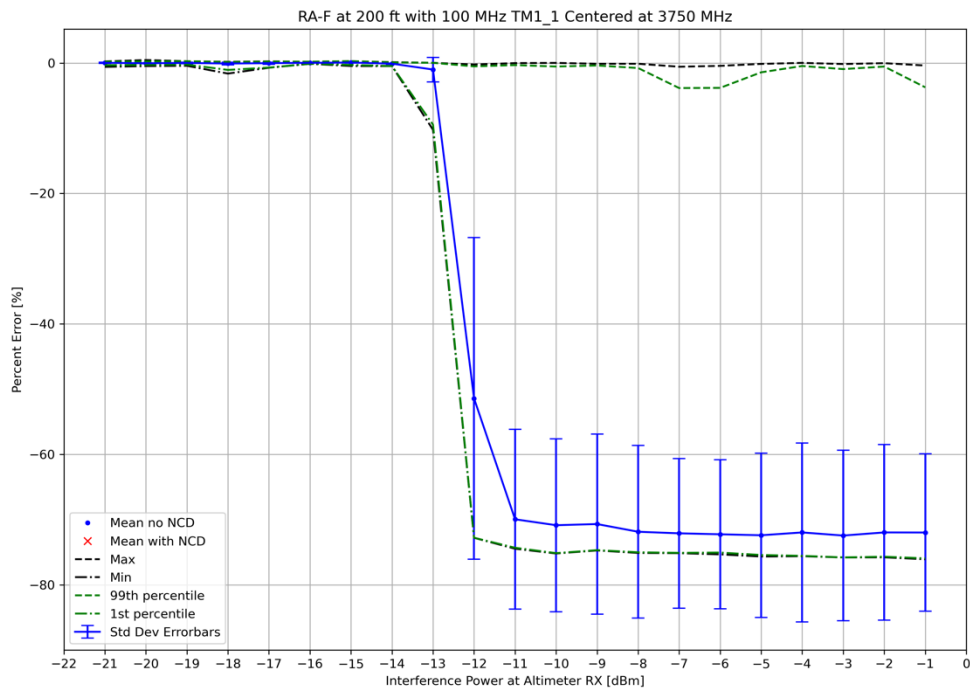


Figure 3-2: UC1 RA-F 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

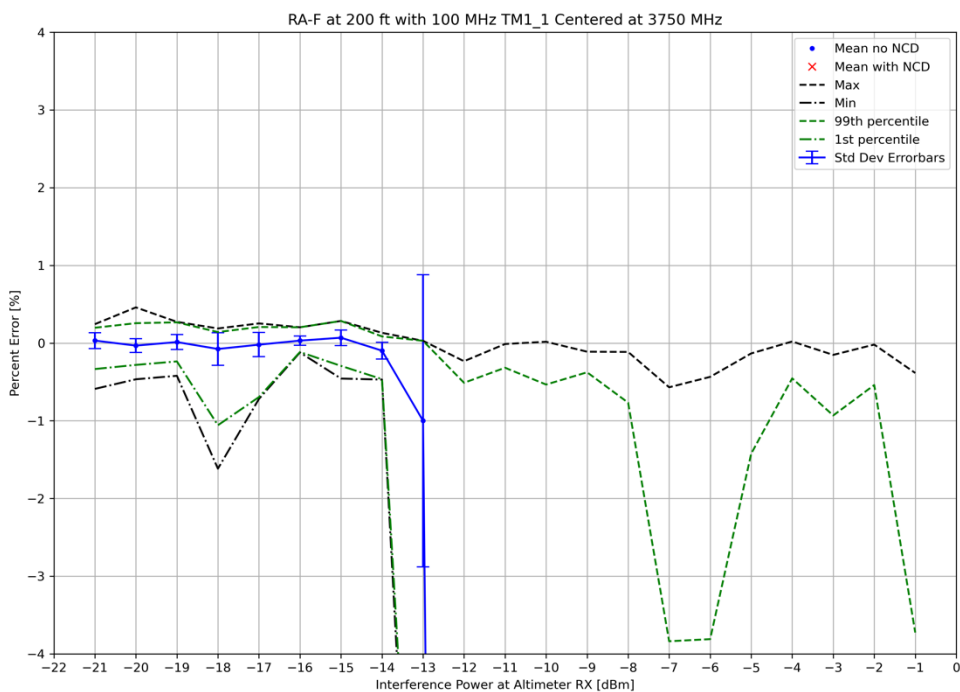


Figure 3-3: UC1 RA-F 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

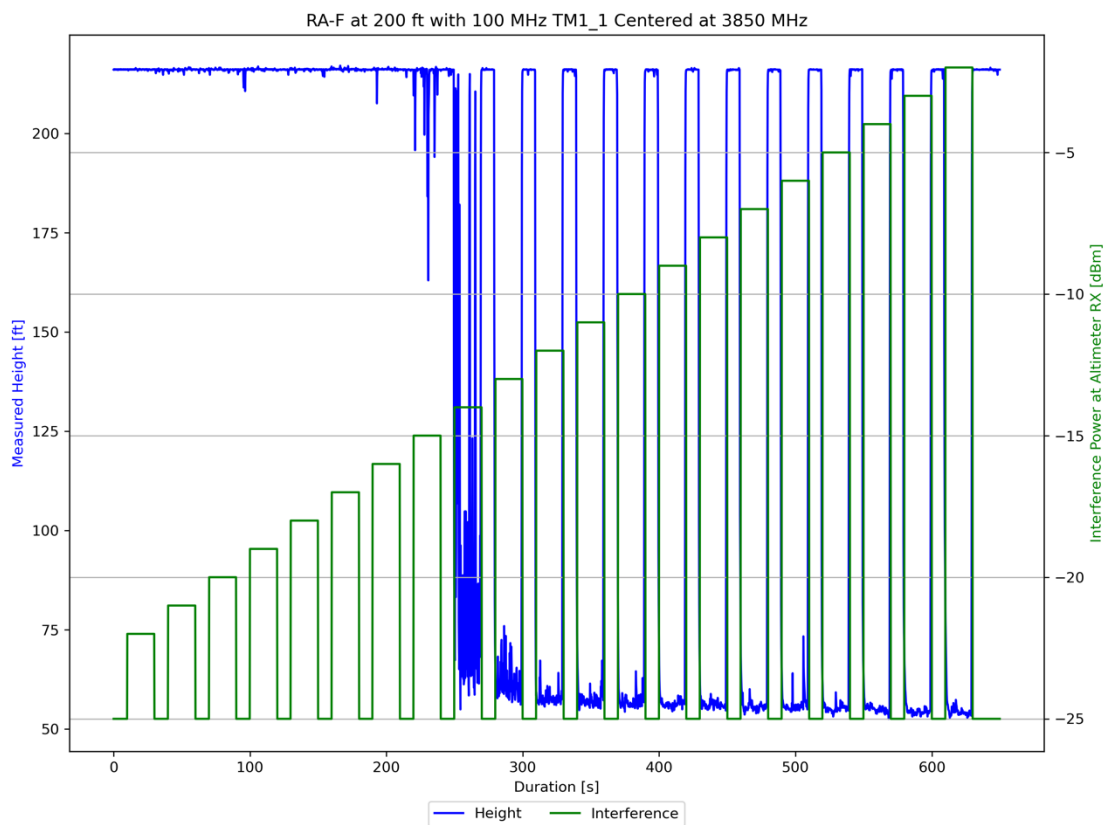


Figure 3-4: UC1 RA-F 200' AGL Time History with TM1.1 at 3850 MHz

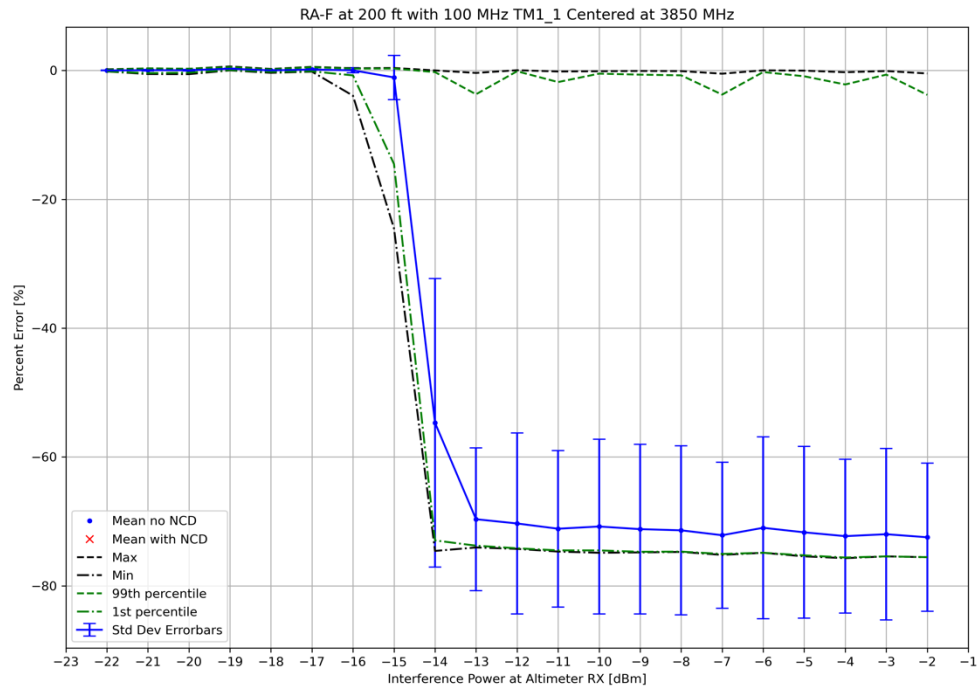


Figure 3-5: UC1 RA-F 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

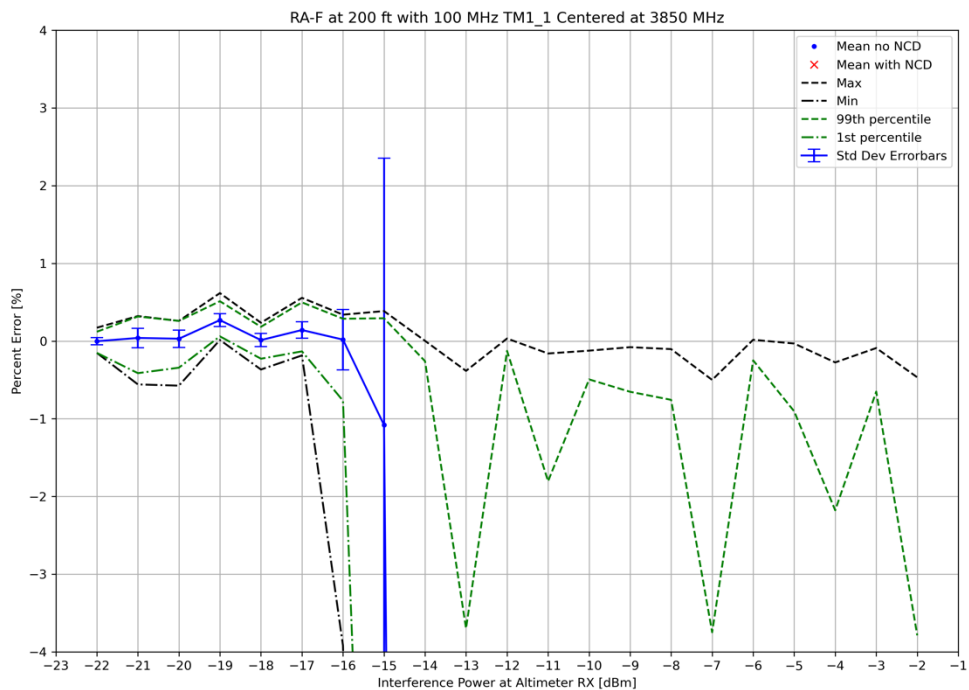


Figure 3-6: UC1 RA-F 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

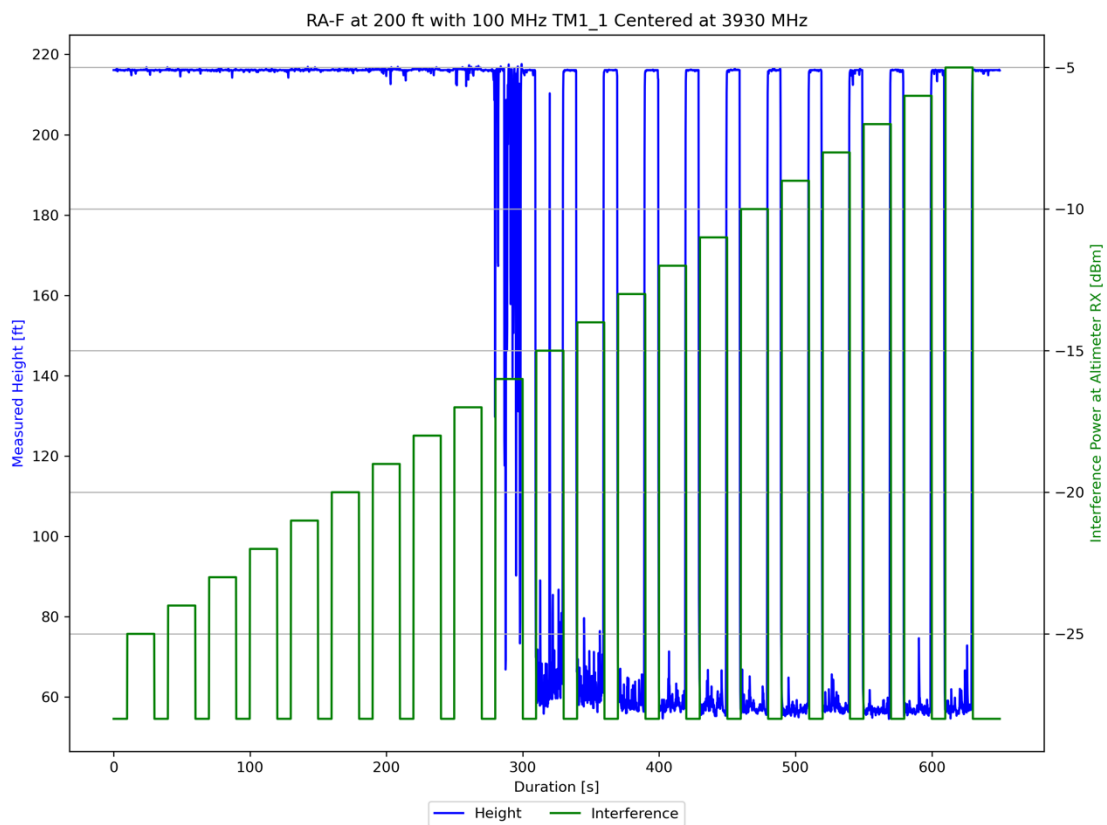


Figure 3-7: UC1 RA-F 200' AGL Time History with TM1.1 at 3930 MHz

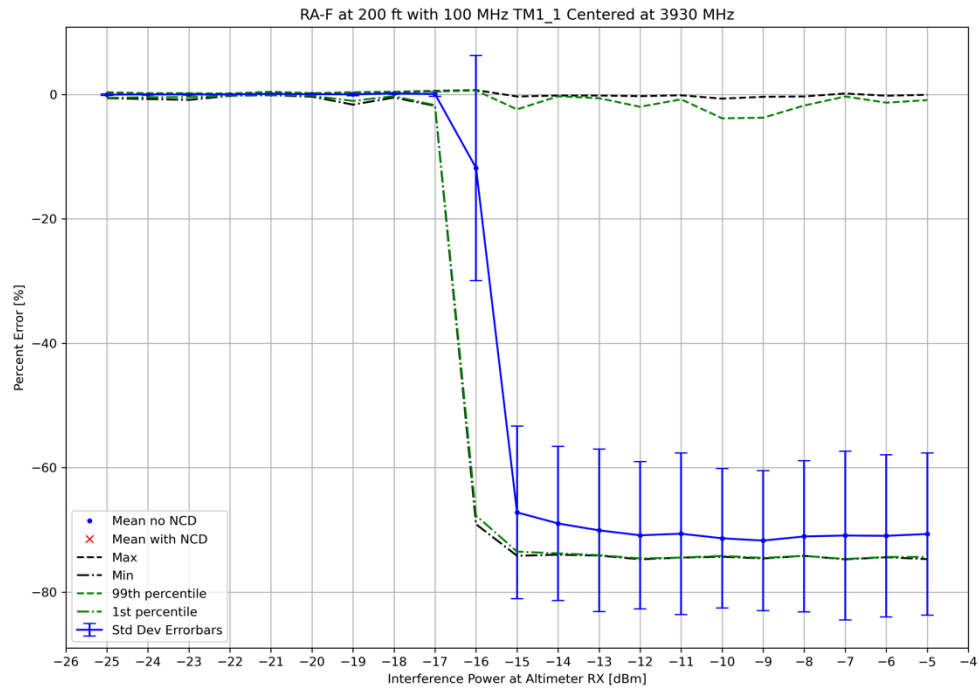


Figure 3-8: UC1 RA-F 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

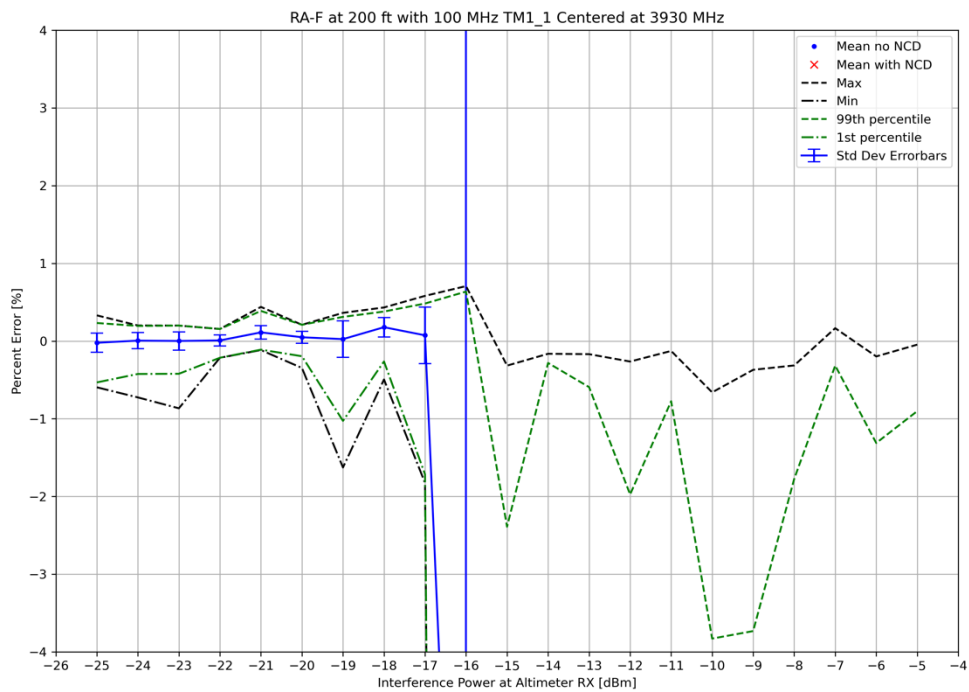


Figure 3-9: UC1 RA-F 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In

3.2.1.3 Altimeter L

Table 3-5: UC1 RA-L 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-10	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-11	No break observed.
3850 MHz	Time History Figure 3-12	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-13	No break observed.
3930 MHz	Time History Figure 3-14	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-15	No break observed.

Center Frequency = 3750 MHz

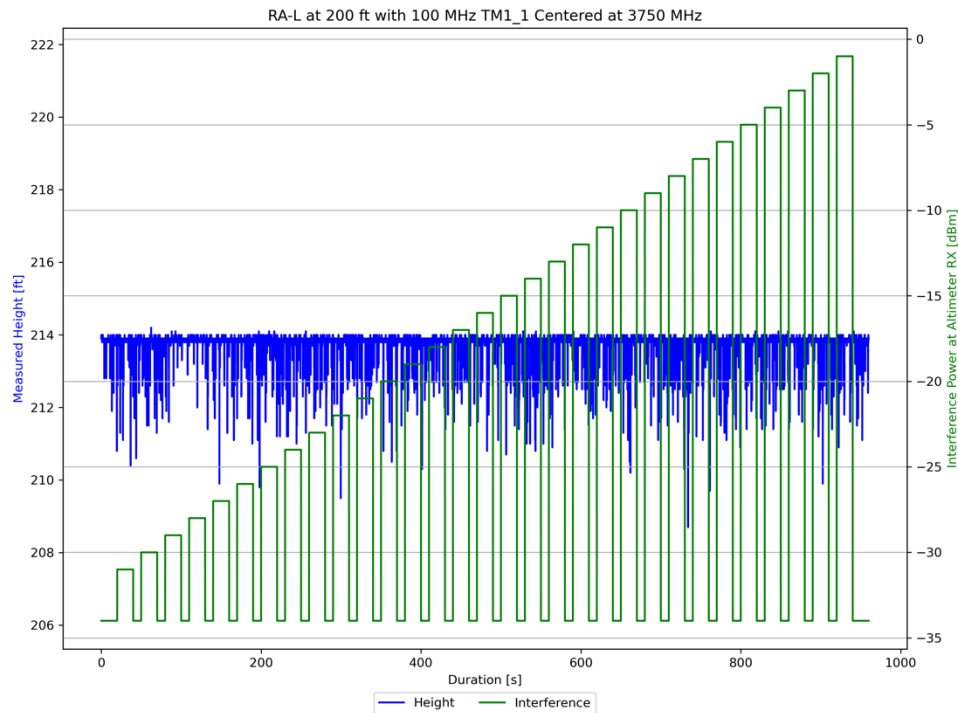


Figure 3-10: UC1 RA-L 200' AGL Time History with TM1.1 at 3750 MHz

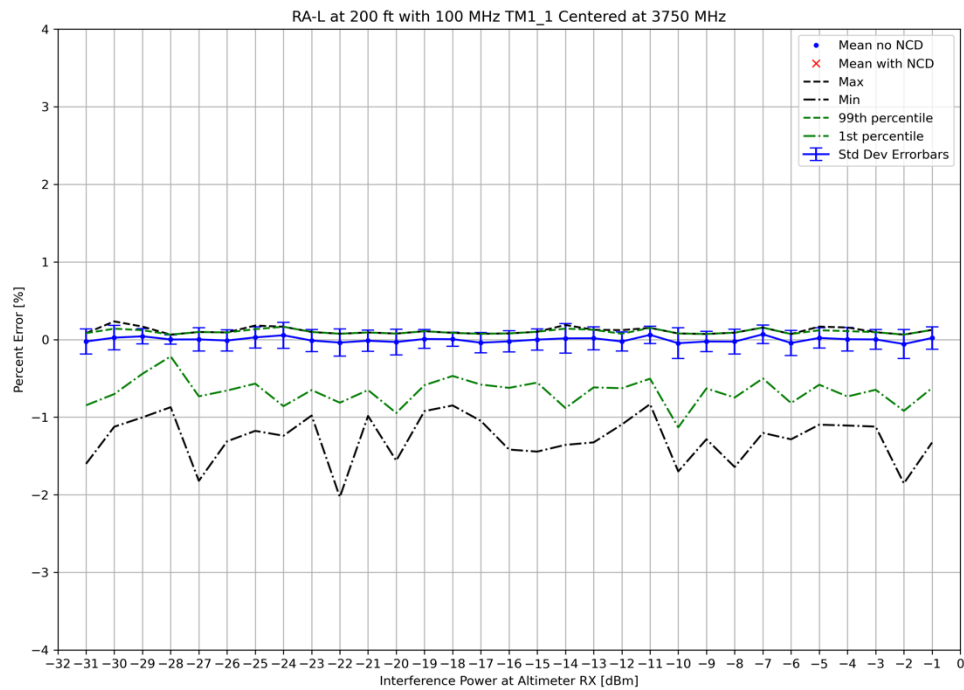


Figure 3-11: UC1 RA-L 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

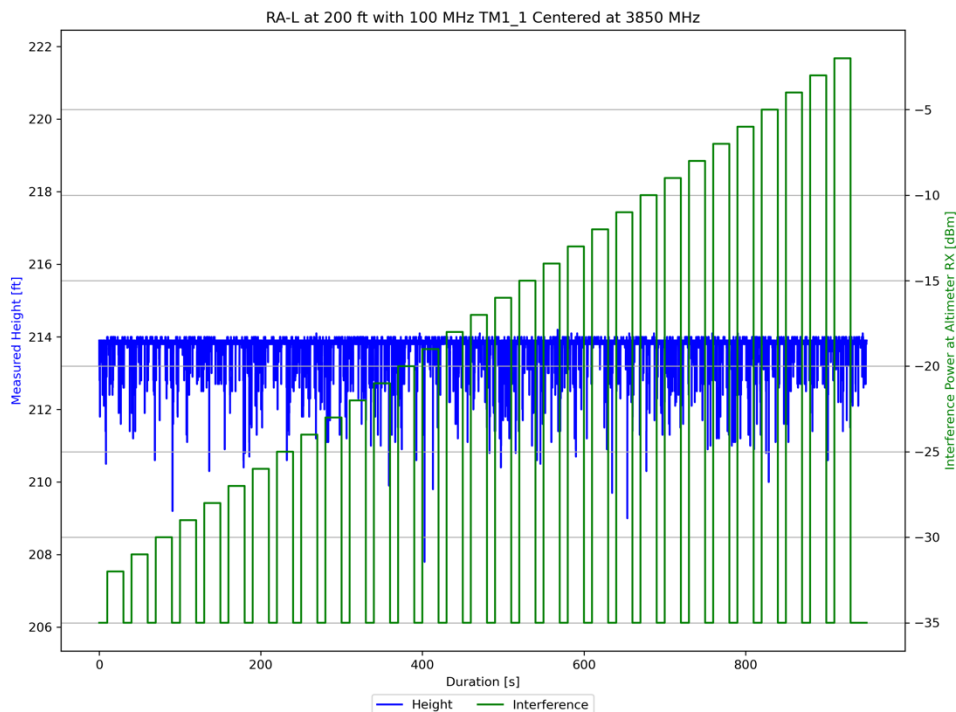


Figure 3-12: UC1 RA-L 200' AGL Time History with TM1.1 at 3850 MHz

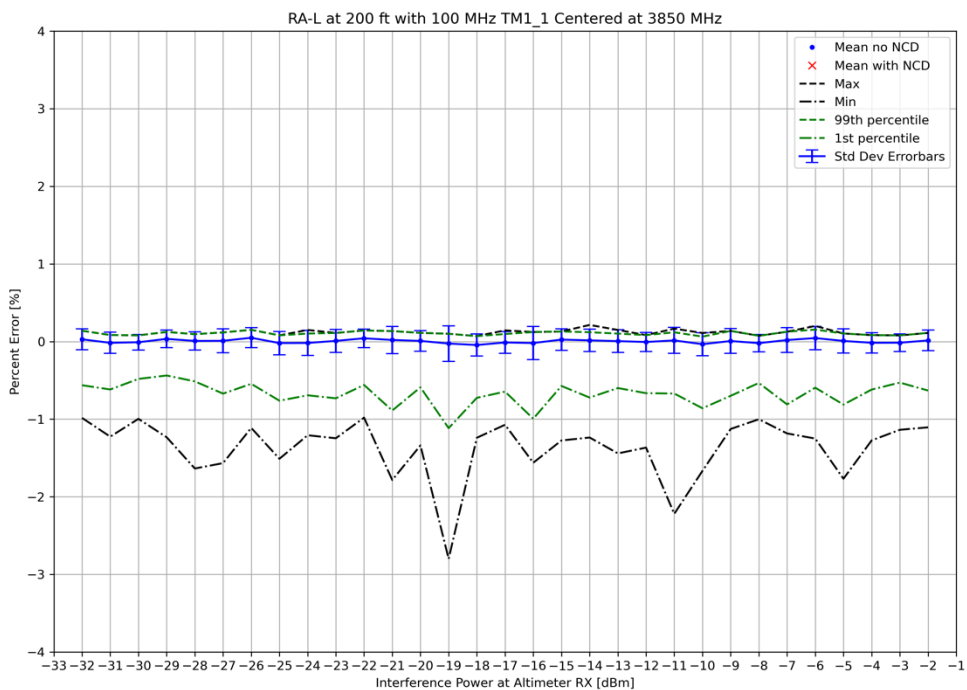


Figure 3-13: UC1 RA-L 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

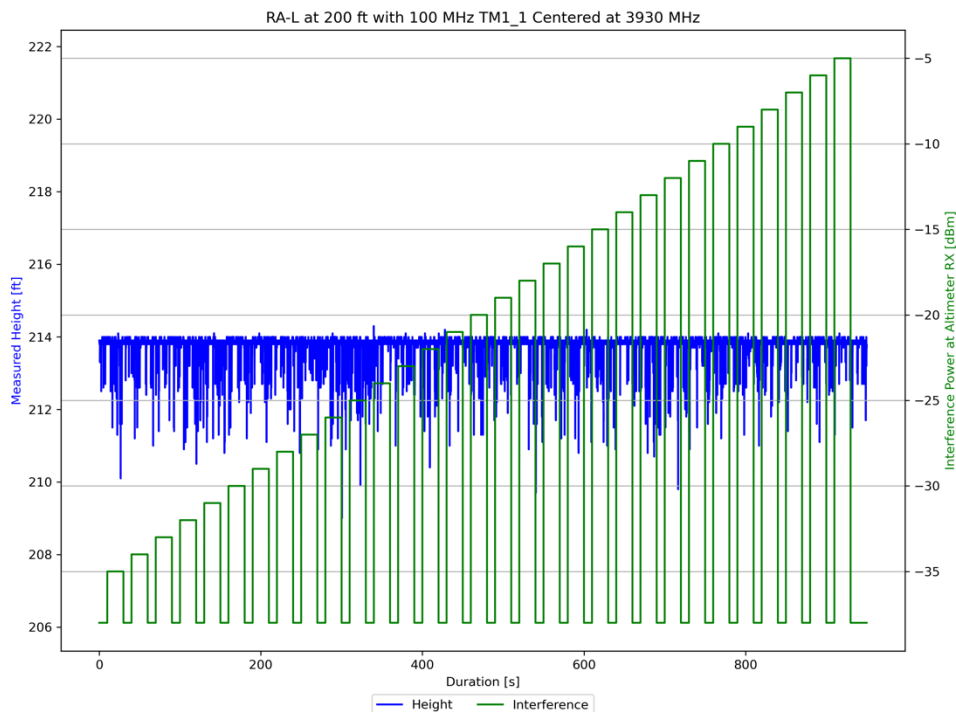


Figure 3-14: UC1 RA-L 200' AGL Time History with TM1.1 at 3930 MHz

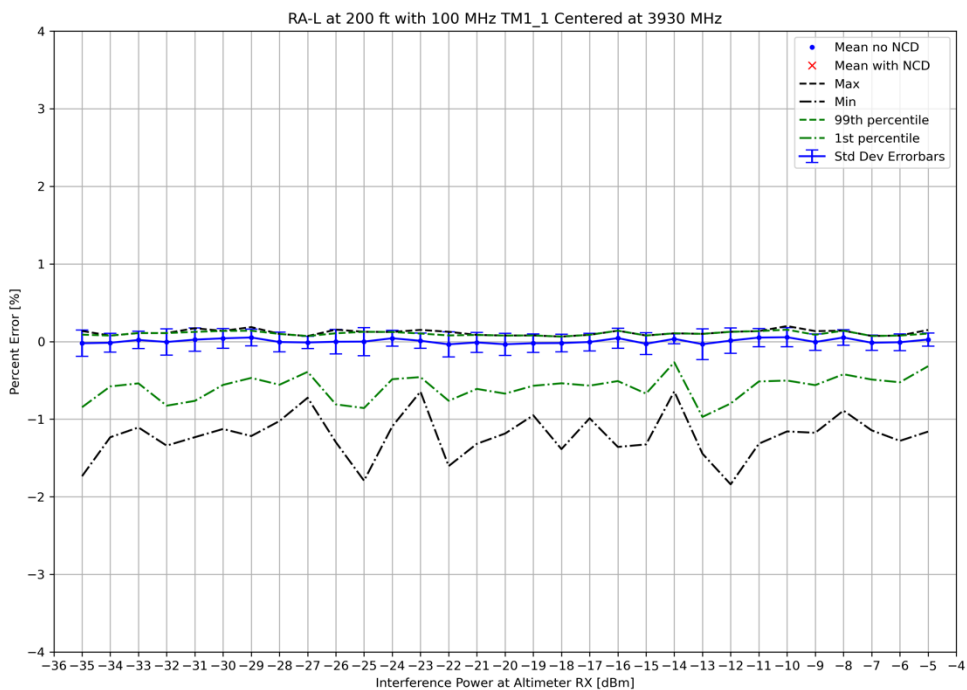


Figure 3-15: UC1 RA-L 200' AGL Statistics with TM1.1 at 3930 MHz

3.2.1.4 Altimeter T

Table 3-6: UC1 RA-T 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-16	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-17	No break observed.
3850 MHz	Time History Figure 3-18	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-19	No break observed.
3930 MHz	Time History Figure 3-20	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-21	No break observed.

Center Frequency = 3750 MHz

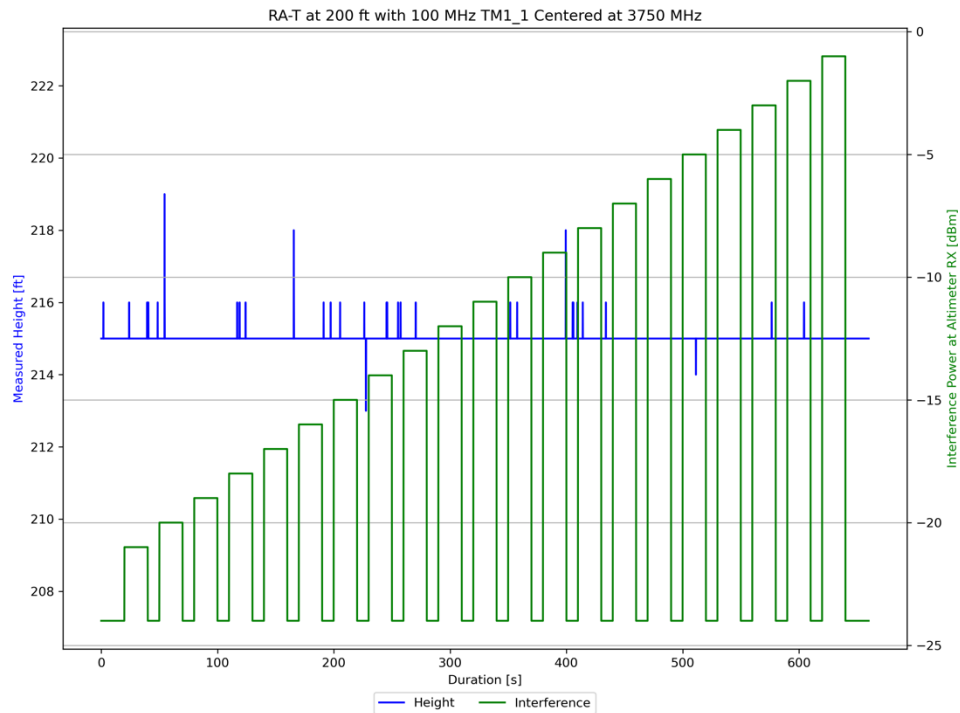


Figure 3-16: UC1 RA-T 200' AGL Time History with TM1.1 at 3750 MHz

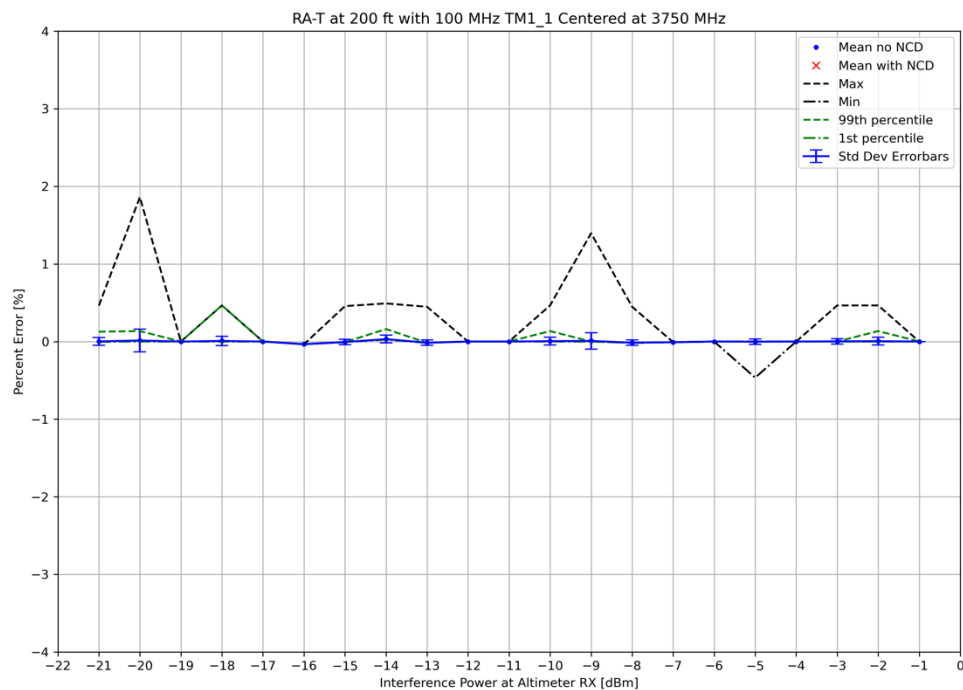


Figure 3-17: UC1 RA-T 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

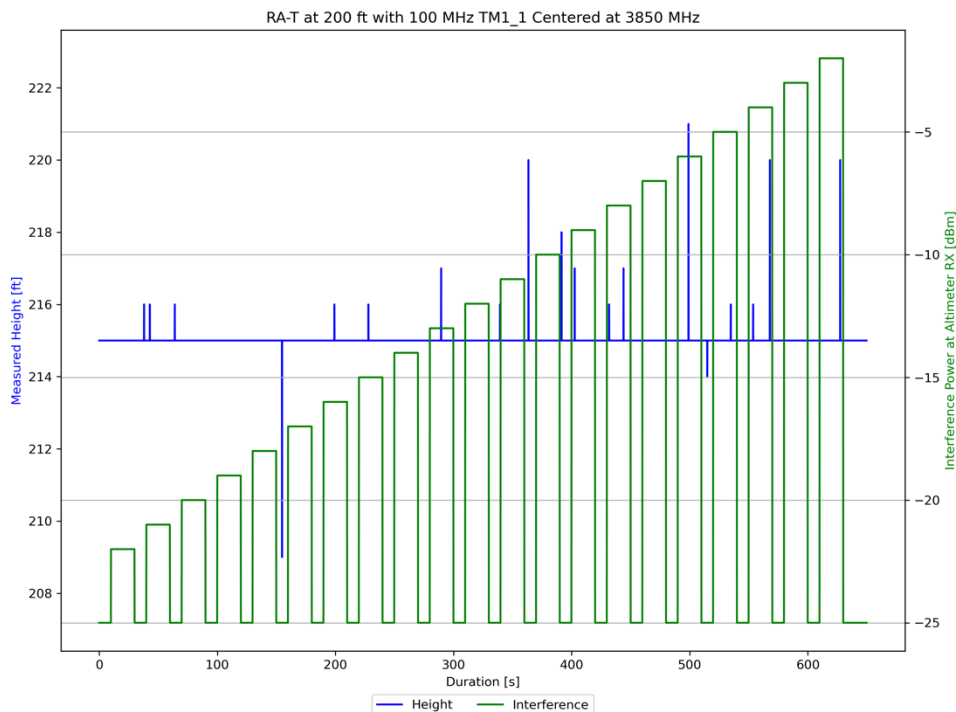


Figure 3-18: UC1 RA-T 200' AGL Time History with TM1.1 at 3850 MHz

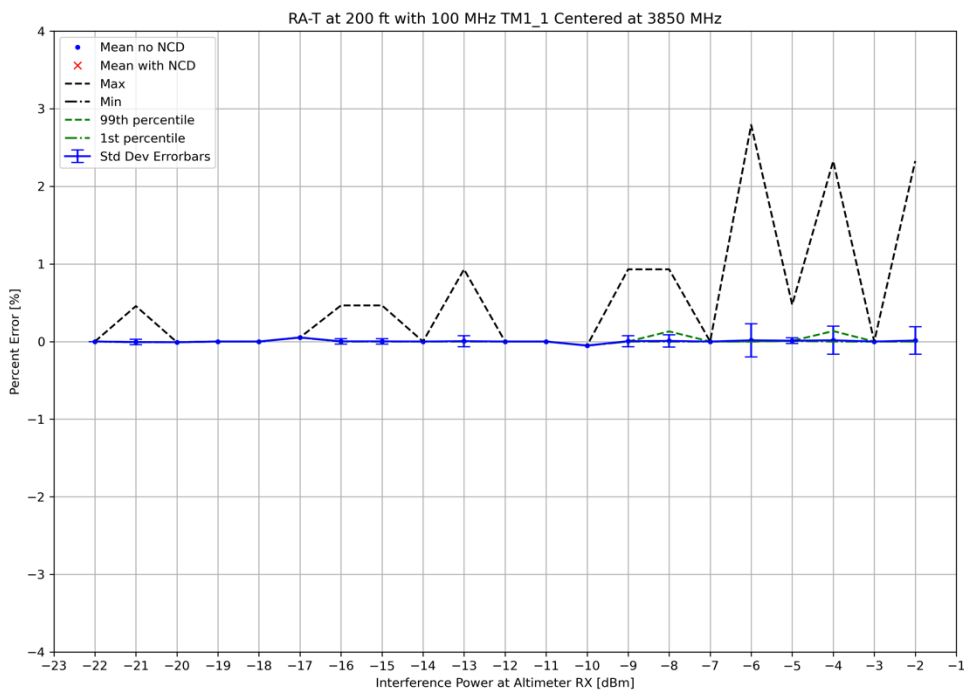


Figure 3-19: UC1 RA-T 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

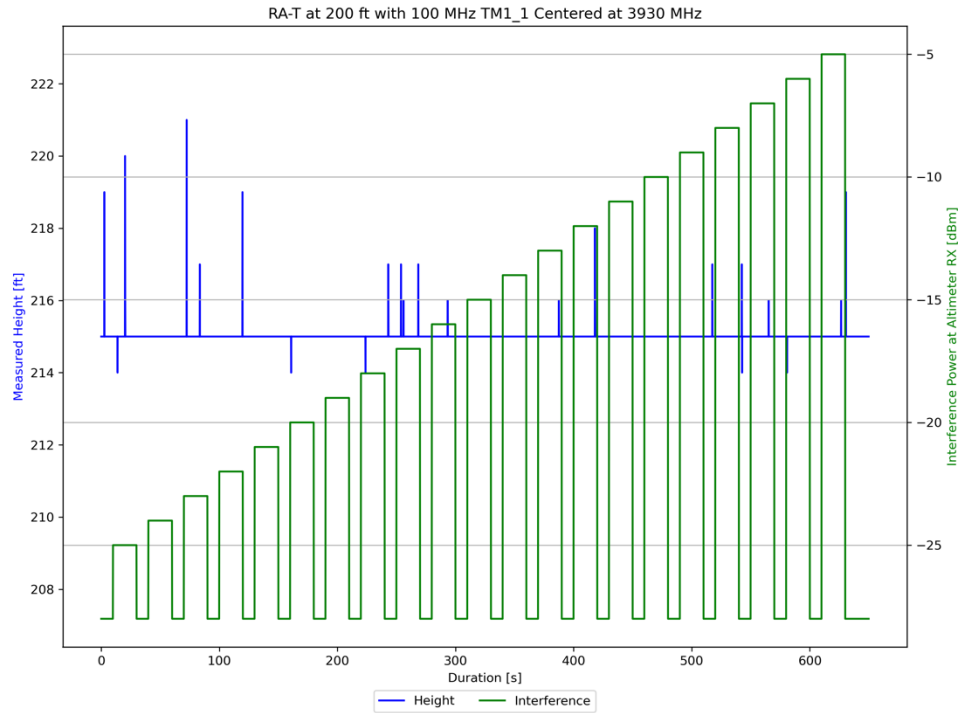


Figure 3-20: UC1 RA-T 200' AGL Time History with TM1.1 at 3930 MHz

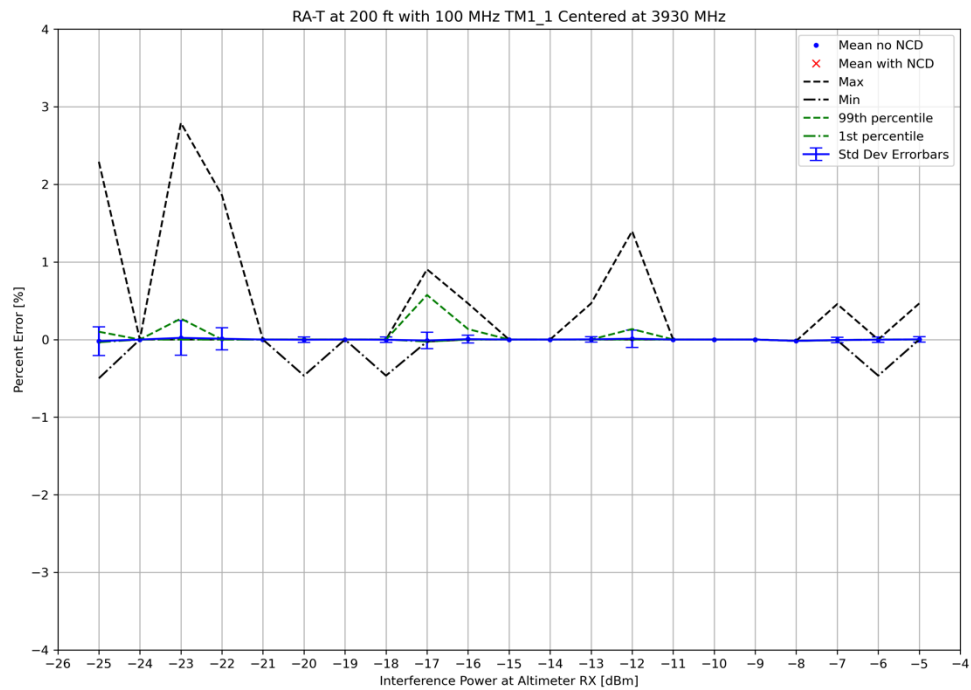


Figure 3-21: UC1 RA-T 200' AGL Statistics with TM1.1 at 3930 MHz

3.2.1.5 Altimeter X

Table 3-7: UC1 RA-X 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-22	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-23	No break observed.
3850 MHz	Time History Figure 3-24	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-25	No break observed.
3930 MHz	Time History Figure 3-26	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-27	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -6 dBm. 1st percentile measured height is less than the -2% criterion threshold at -5 dBm.

Center Frequency = 3750 MHz

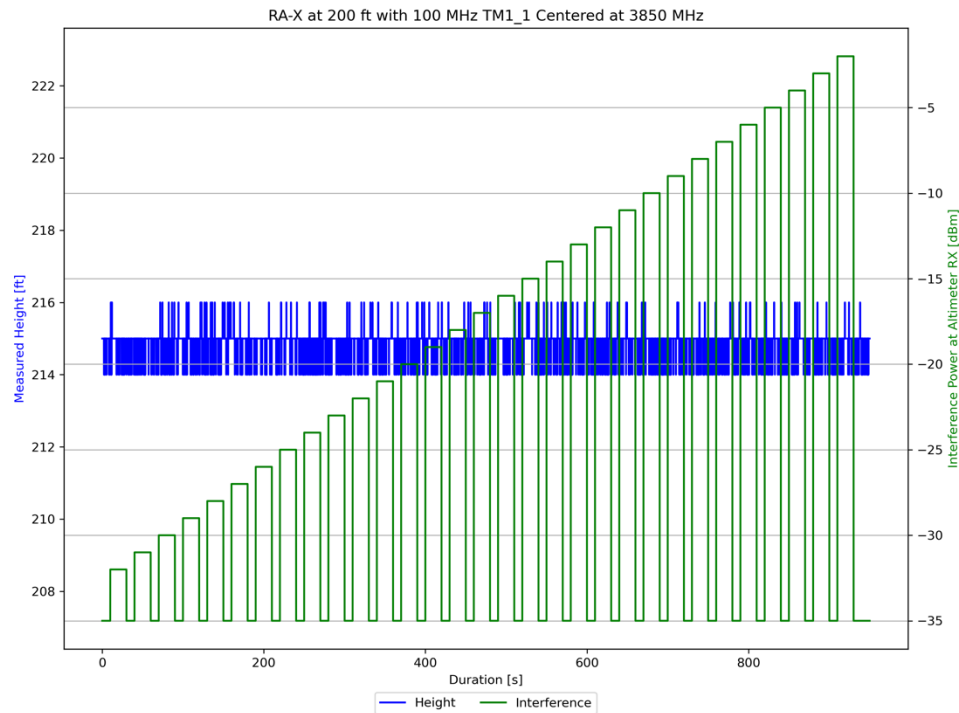


Figure 3-22: UC1 RA-X 200' AGL Time History with TM1.1 at 3750 MHz

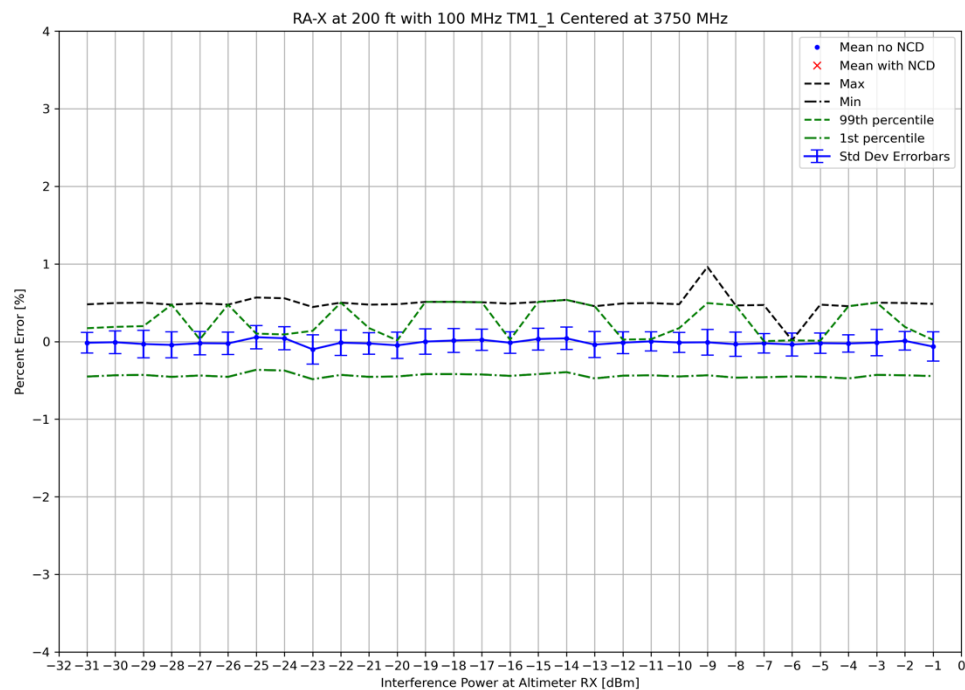


Figure 3-23: UC1 RA-X 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

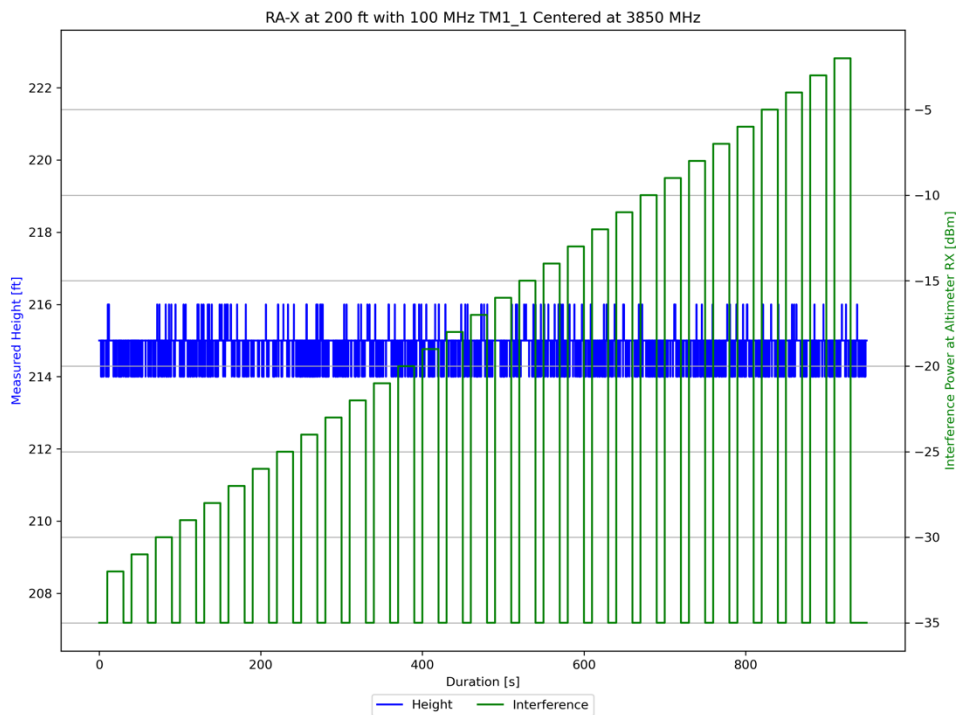


Figure 3-24: UC1 RA-X 200' AGL Time History with TM1.1 at 3850 MHz

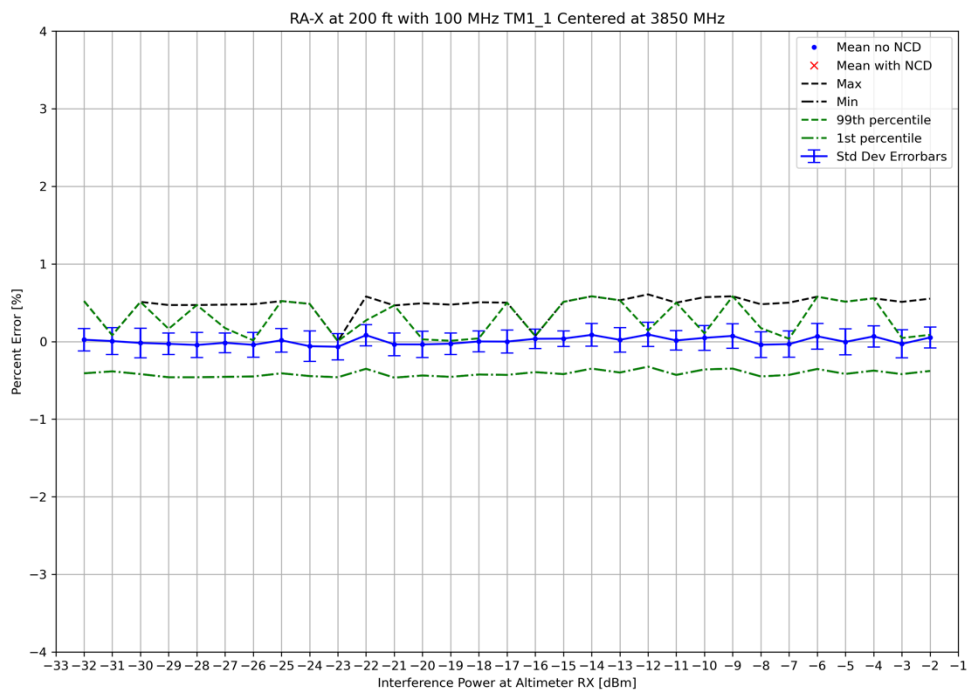


Figure 3-25: UC1 RA-X 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

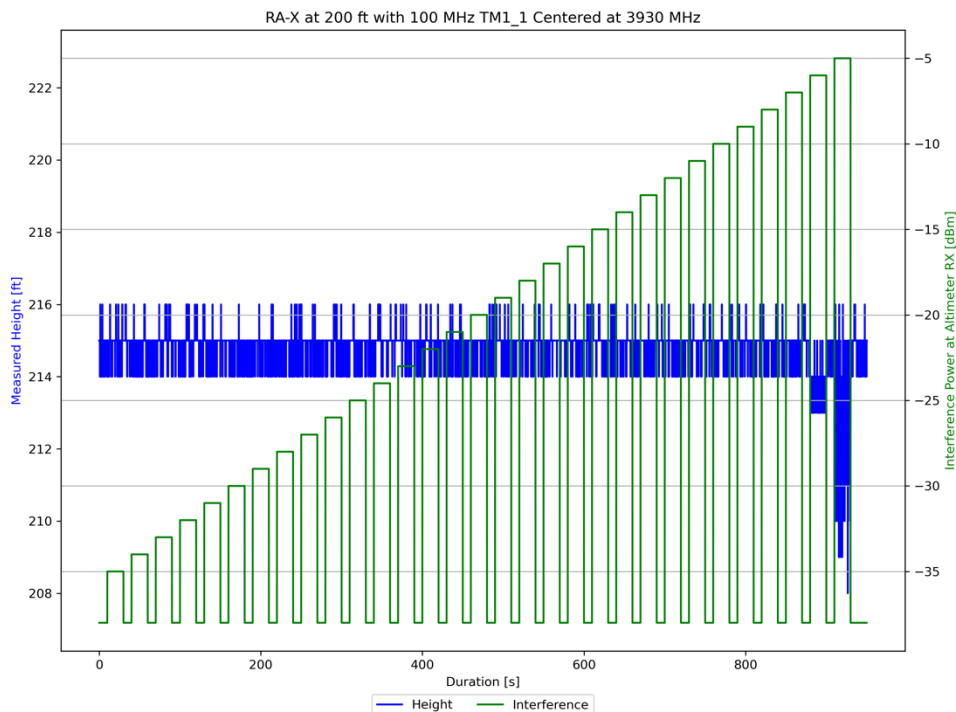


Figure 3-26: UC1 RA-X 200' AGL Time History with TM1.1 at 3930 MHz

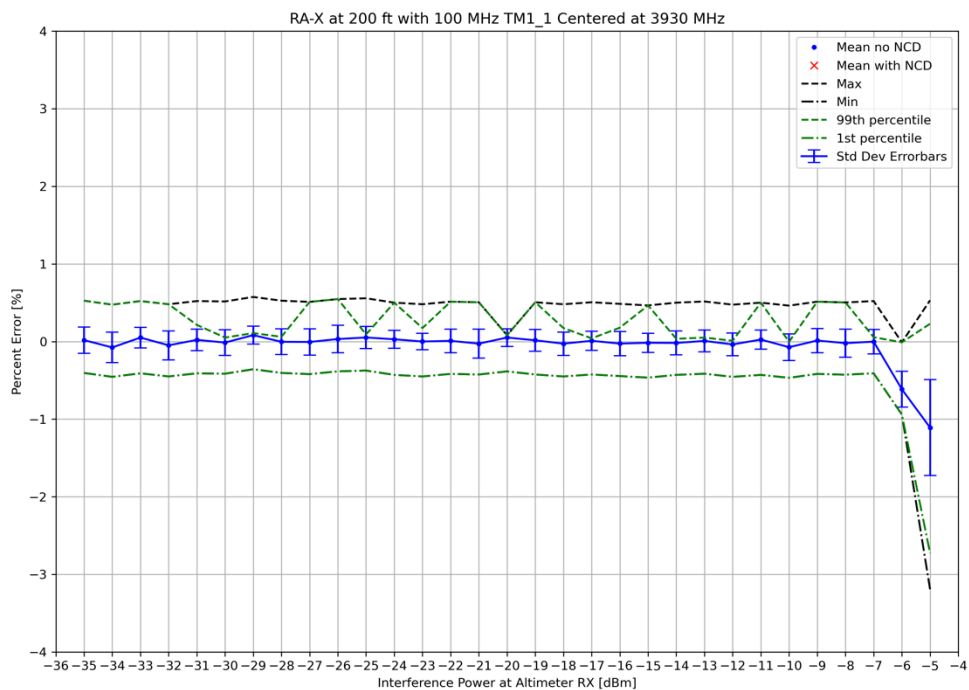


Figure 3-27: UC1 RA-X 200' AGL Statistics with TM1.1 at 3930 MHz

3.2.1.6 Altimeter Y

Table 3-8: UC1 RA-Y 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-28	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-29 Figure 3-30	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -9 dBm. 1st percentile measured height is less than the -2% criterion threshold at -9 dBm.
3850 MHz	Time History Figure 3-31	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-32 Figure 3-33	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -8 dBm. 1st percentile measured height is less than the -2% criterion threshold at -8 dBm.
3930 MHz	Time History Figure 3-34	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-35 Figure 3-36	Mean error exceeds the $\pm 0.5\%$ criterion threshold at -5 dBm. 1st percentile measured height is less than the -2% criterion threshold at -5 dBm.

Center Frequency = 3750 MHz

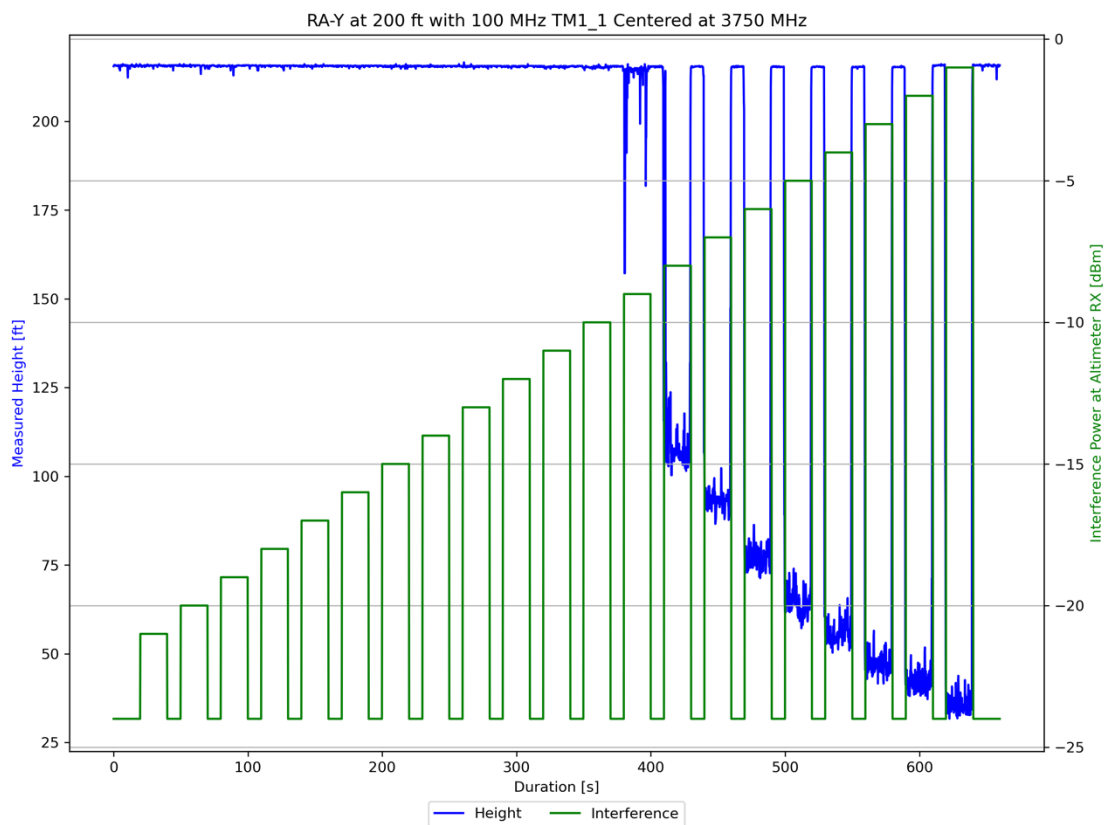


Figure 3-28: UC1 RA-Y 200' AGL Time History with TM1.1 at 3750 MHz

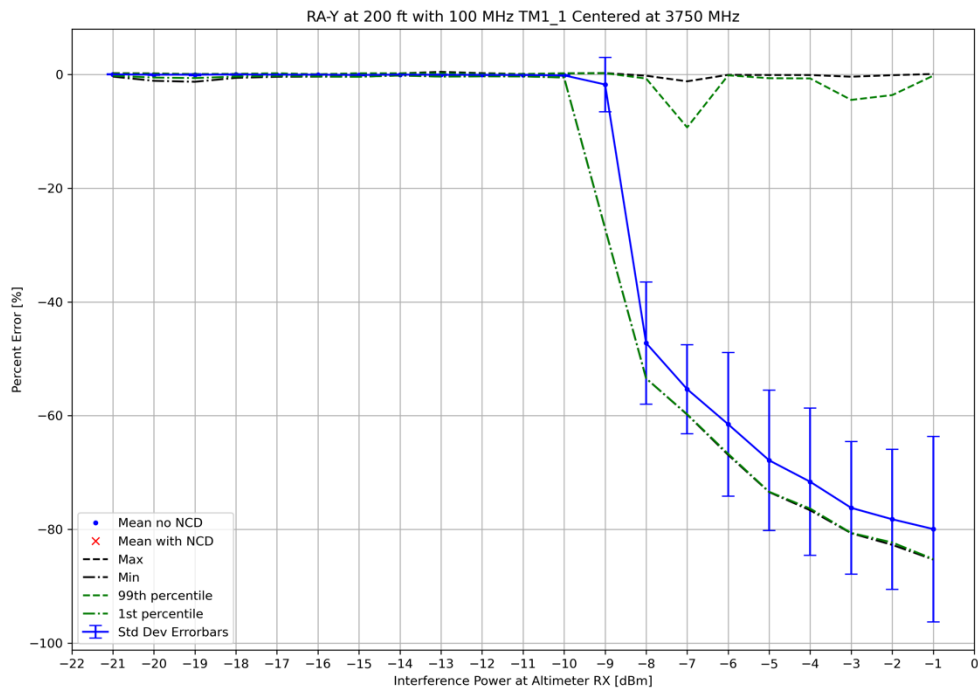


Figure 3-29: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

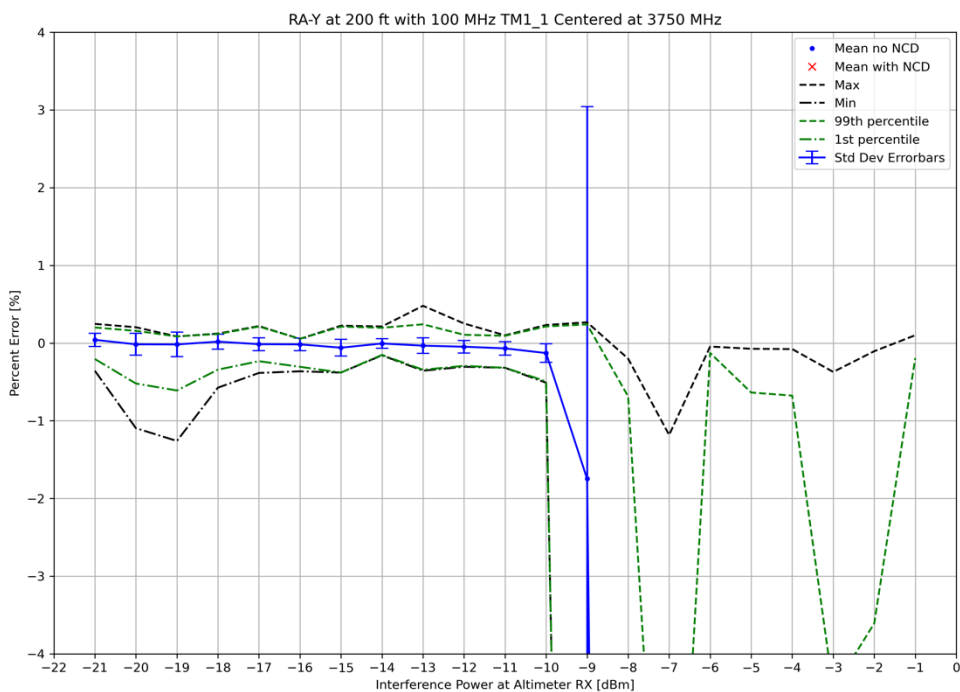


Figure 3-30: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

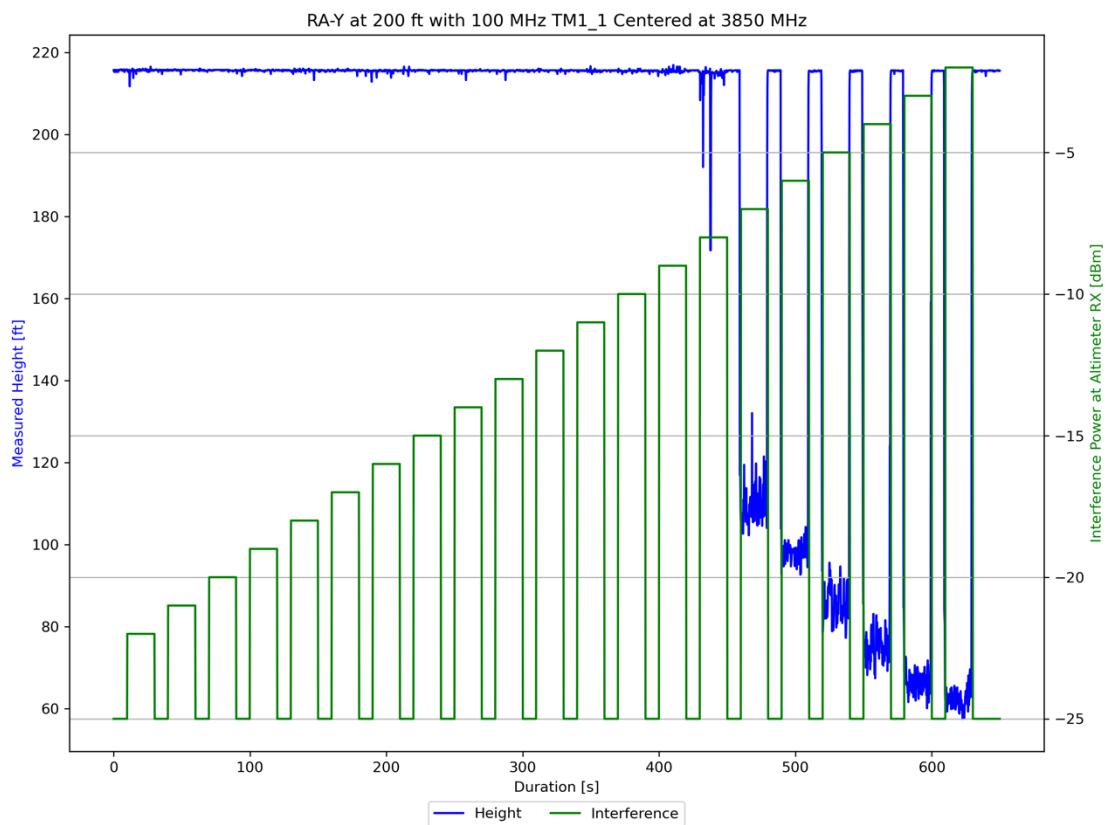


Figure 3-31: UC1 RA-Y 200' AGL Time History with TM1.1 at 3850 MHz

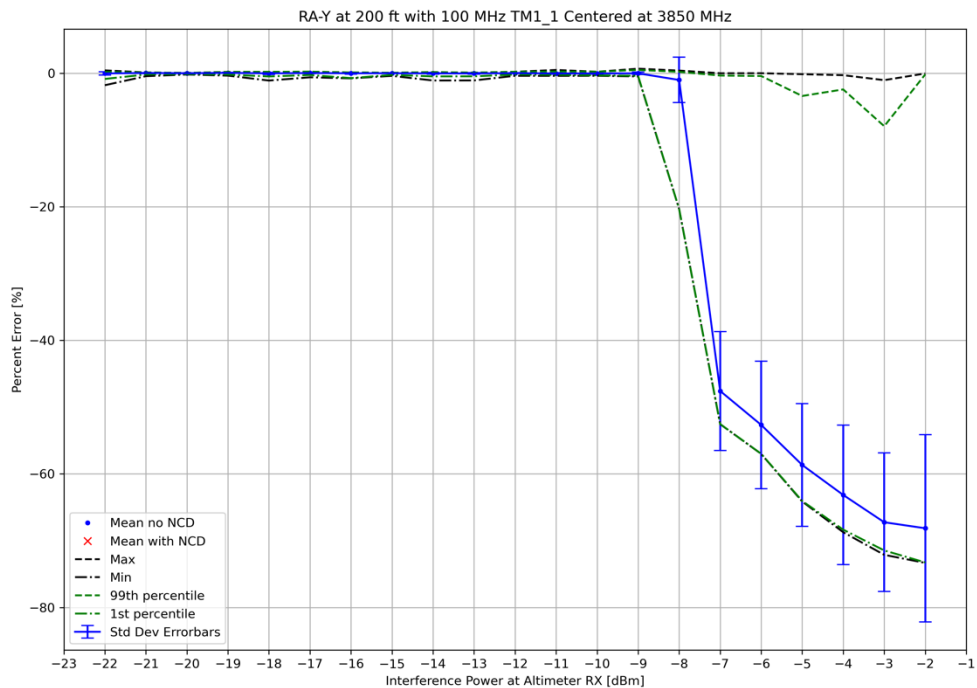


Figure 3-32: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

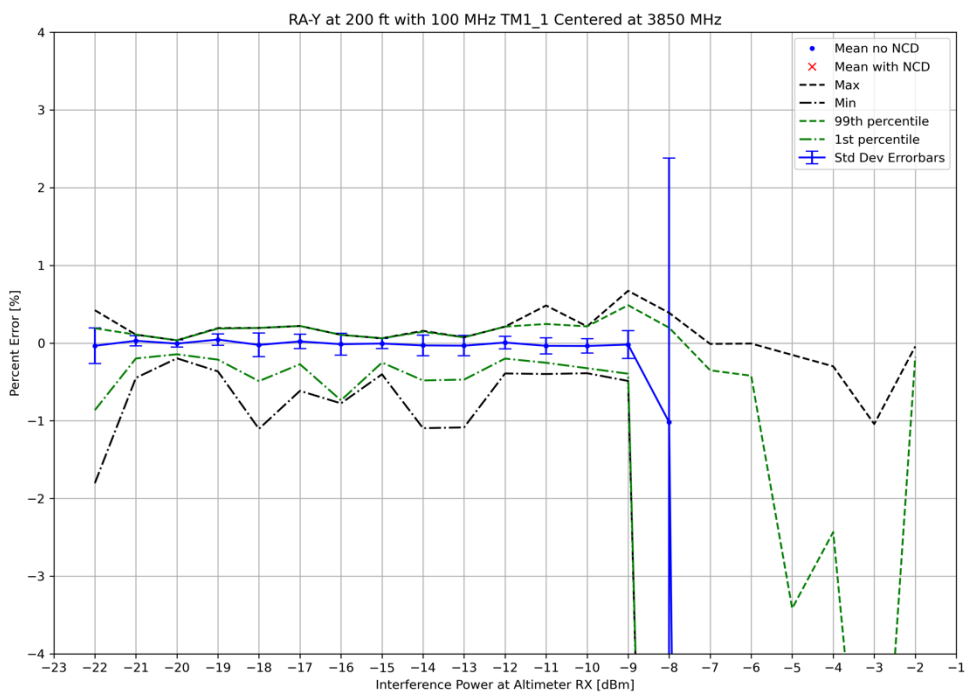


Figure 3-33: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

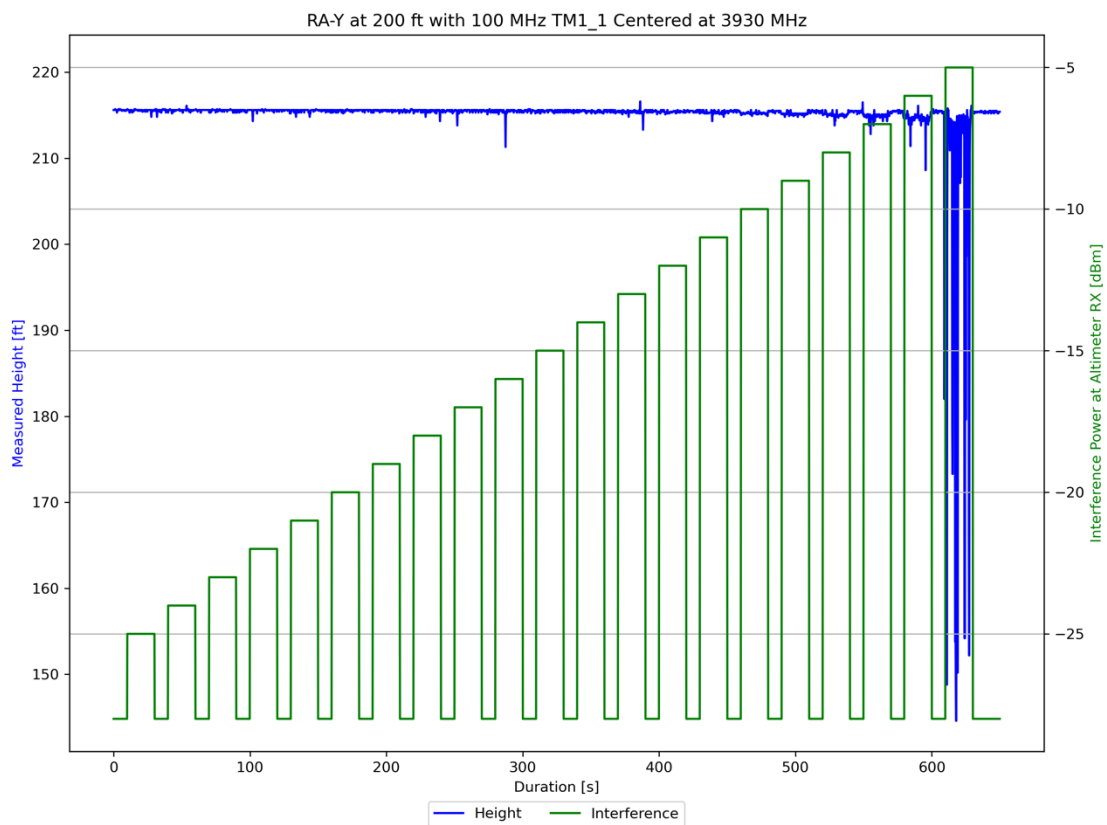


Figure 3-34: UC1 RA-Y 200' AGL Time History with TM1.1 at 3930 MHz

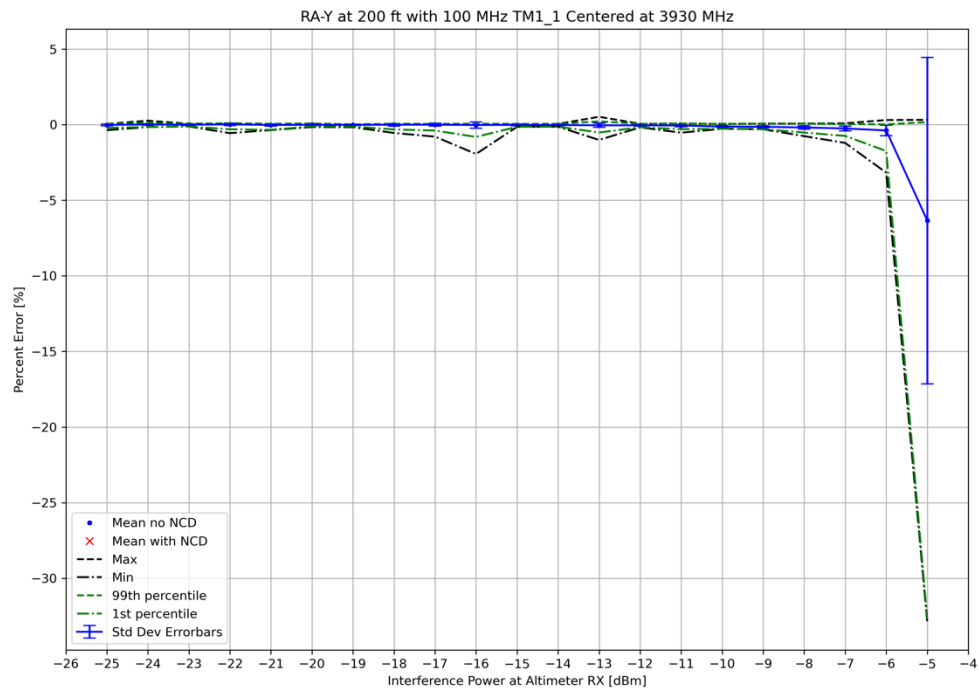


Figure 3-35: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

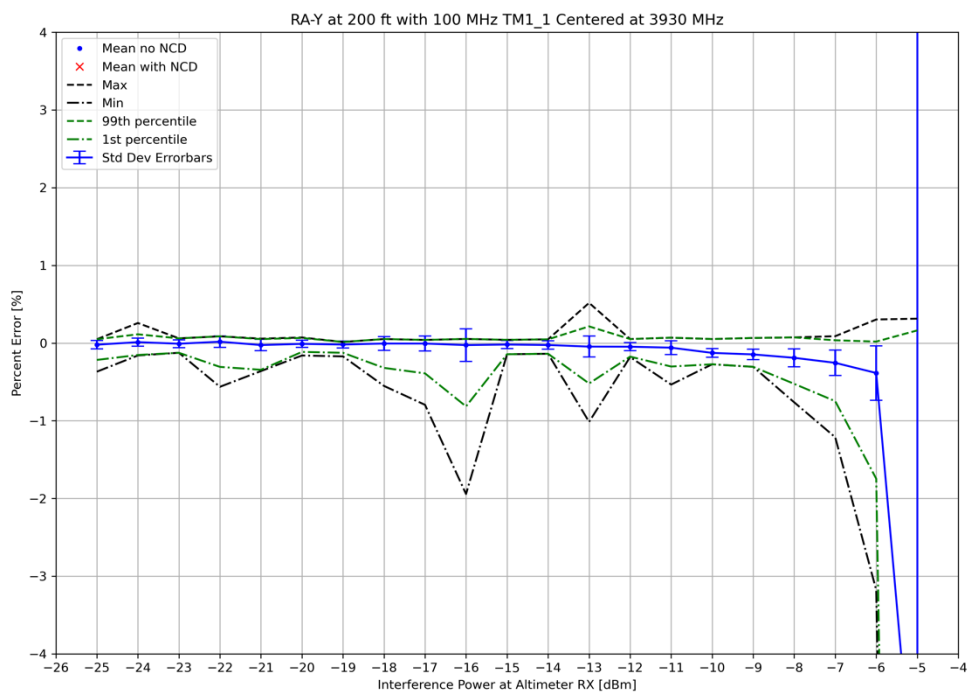


Figure 3-36: UC1 RA-Y 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In